Chapter 5: Computer Methods

5.0 SUMMARY

This chapter explains the use of approved public domain and ***Alternative Calculation Method (ACM)*** computer programs to show compliance with the annual energy budget requirement of the *Energy Efficiency Standards* (Standards). These ***computer methods*** represent one of two basic compliance paths explained in this chapter and Chapter 3.

The introductory section outlines the basis of the computer method approach and the ACM approval process for the use of computer programs with the Standards. Following sections summarize the compliance procedure with computer methods.

Part 5.4 of this Chapter describes computer input values and proposed design modeling techniques. Guidelines for special modeling cases such as zonal controls, controlled ventilation crawl spaces and sunspaces are also contained in Part 5.4. (Input descriptions relating to water heating calculations are contained in Chapter 5.) Part 5.5 outlines standardized computer method compliance reports using the public domain program (CALRES2) printout as illustration. The final section summarizes the computer assumptions that are used to generate the annual energy budget. Part 5.6 describes how the energy budget is determined.

The compliance supplement of each approved computer method provides important information regarding the use of that program for showing compliance with the Standards.

CHAPTER OVERVIEW:

Applicable sections of the California Code of Regulations, Title 24, Part 1: 10-108, 10-109, 10-110; Part 6: 151.

5.1 INTRODUCTION

Computer methods are computer programs approved by the California Energy Commission as being capable of calculating space conditioning and water heating energy use. The methods *simulate* or *model* the thermal behavior of buildings by calculating heat flows into and out of the various thermal zones of the building. The Warren-Alquist Act calls for the establishment of "performance standards" which predict and compare energy use of buildings. Because of their relative accuracy in analyzing annual space conditioning and water heating energy use of different building conservation features, levels and techniques, computer methods are the basis of performance standards.

A computer method can perform a significant number of calculations to project the interactive thermal effects of many different building components in conjunction with specific outdoor weather conditions. The calculations include:

- Heat gain and heat loss through walls, roof/ceilings, floors, fenestration and doors
- Solar gain through fenestration as affected by orientation, fixed shading or operable shading devices
- Natural ventilation by operable windows and infiltration through cracks and porous surfaces in the building envelope
- Heat storage effects of different types of thermal mass in buildings with large amounts of mass (e.g., passive solar buildings)
- Efficiencies of mechanical heating and cooling equipment and duct systems

The prescriptive packages (Chapter 3) were derived by the Commission from the results of building energy analysis studies using the Commission's reference computer method.

Computer methods are generally the most detailed and flexible compliance path. The energy performance of a proposed building design can be calculated according to actual building geometry and site placement. Credit for certain conservation features, such as improved duct efficiency or reduced building envelope leakage, cannot be taken in the prescriptive packages, but can be evaluated with an approved computer method.

> **NOTE:**
>
> Use of a computer method may require special documentation associated with particular features such as radiant barriers or high thermal mass levels. See Part 5.5 for required documentation. Similarly, compliance credit for features, such as improved duct efficiency or reduced building envelope air leakage, that require diagnostic testing and field verification also require special documentation and processing. See Section 4.3 for diagnostic testing and field verification requirements.

Approval of Computer Methods

For any computer method to be used for compliance with the Standards, the method must first be *approved* by the Commission. Approval involves the demonstration of minimum modeling capabilities and program documentation. The program must be able to:

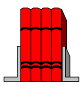
- Automatically calculate the ***energy budget*** based upon the ***standard design*** (see Part 5.2)
- Calculate the energy use of the proposed design in accordance with specific fixed and restricted inputs
- Perform basic water heating calculations (see Chapter 6)
- Print the appropriate standardized compliance reports (Part 5.5).

Modeling capabilities are tested by using the program to calculate the energy use of certain prototype buildings under specific conditions. The results are then compared with the results from the Commission's reference computer method.

The Commission approves the alternative calculation method according to the procedures outlined in Title 24, Part 1, Sections 10-108 through 10-110. The procedures are detailed in the *Residential Alternative Calculation Methods Approval Manual.*

The Commission periodically updates a listing of approved computer programs. This list may be obtained from the Commission's Publications Office or by calling the Energy Hotline at (800) 772-3300, and can be inserted into this manual as Appendix F.

5.2 COMPLIANCE WITH A COMPUTER METHOD



Energy Code

Combined Energy Budget (Section 151(b)

Performance Standards*. A building complies with the performance standard if its combined calculated depletable energy use for water heating (Section 151(b)1.) and space conditioning (Section 151(b)2.) is less than or equal to the combined maximum allowable energy use for both water heating and space conditioning, even if the building fails to meet either the water heating or space conditioning budget alone.*

1. *Water heating budgets. The budgets for water heating systems are those calculated from Equation No. 1-N [see Chapter 6].*

2. *Space conditioning budgets. The space conditioning budgets for each climate zone shall be the calculated consumption of energy from depletable sources required for space conditioning in buildings in which the basic requirements of Section 151(a) and the measures in alternative component package D are installed. To determine the space conditioning budget, use an approved calculation method.*

Compliance/
Plan Check

Combined Energy Budget: Space Conditioning and Water Heating Energy Use

Each approved computer method automatically generates an ***energy budget*** by calculating the annual energy use of the ***standard design***, a version of the proposed building incorporating all the conservation features of prescriptive Package D (see Chapter 3). There are two basic components to the energy budget: space conditioning and water heating. Space conditioning is further divided into space heating and space cooling.

A building complies with the Standards if the predicted source ***energy use*** of the ***proposed design*** is the same or less than the combined annual energy budget for space conditioning and water heating of the standard design. As explained in Chapter 6, the energy budget for water heating energy use varies for each dwelling unit depending on the total conditioned floor area. The budget for space heating and cooling varies according to specific characteristics of the proposed building design.

Since the energy budget for the standard design is derived by assuming equal distribution of fenestration area in all four cardinal orientations, the energy budget remains the same regardless of how the actual building is oriented. Variables which affect the energy budget are:

- Conditioned floor area
- Conditioned volume
- Gross roof/ceiling area
- Gross wall area
- Slab edge length
- Conditioned Slab-on-grade area
- Raised floor area over crawl space
- Raised floor area over open space
- Heating system type: Gas or electric
- Cooling system type: Split or single package
- Space conditioning distribution system type
- Climate zone

All other building-related inputs such as area and type of fenestration products, ventilation, HVAC efficiencies and duct efficiencies are automatically fixed in the standard design building according to the Package D requirements and are not accessible for modification by program users.

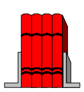
ENERGY SUMMARY (kBtu/ft^2-yr)	Standard Design Energy Budget	Proposed Design Energy Use
Space Heating	12.34	12.63
Space Cooling	8.97	7.12
Water Heating	11.76	11.76
Total	33.07	31.51

Figure 5-1: CALRES2 Example Energy Use Summary on C-2R (Page 1)

Assumptions used by the computer methods in generating the energy budget are summarized in Part 5.6.

The energy budget and energy use for a building is summarized in an ***Energy Summary*** on the Computer Method Summary (C-2R) form illustrated in Part 5.5 and Figure 5-1. The ***Standard Design Energy Budget*** is calculated according to the rules and assumptions explained in Part 5.6, and represents the total allowable energy budget for the building.

The *Proposed Design Energy Use* must be equal to or less than that of the Standard Design Energy Budget for the building to comply.



Energy Code

Compliance Demonstration (Section 151(c))

Compliance Demonstration Requirements for Performance Standards*. The application for a building permit shall include documentation which demonstrates, using an approved calculation method, that the new building has been designed so that its energy use from depletable energy sources does not exceed the combined water heating and space conditioning energy budgets for the appropriate climate zone.*

Compliance Demonstration

Compliance/
Plan Check

Although any one or two components of the energy use may be higher than the same component in the energy budget (e.g., 12.63 kBtu/ft^2-yr versus 12.34 kBtu/ft^2-yr space heating), the *combined* energy use of the Proposed Design must be less than or equal to the *combined* energy budget of the Standard Design (e.g., 31.51 versus 33.07 kBtu/ft^2-yr). In this way, trade-offs can be made among water heating, space heating and space cooling energy use (see Section 151(b) of the Standards).

Additions

An approved computer method may be used to show compliance of an addition alone, or be used to show compliance of an addition accounting for the energy performance of the existing building. These approaches are explained in Chapter 7, Parts 7.2 and 7.3.

5.3 GENERAL COMPLIANCE PROCEDURE

Any approved computer method may be used to comply with the Standards. The following steps are a general outline of the typical computer method procedure:

1. Collect all necessary data—areas of fenestration products, walls, doors, roofs, ceilings and floors, construction assemblies, solar heat gain coefficients, equipment efficiencies, water heating information—from drawings and specifications. Although most computer methods require the same basic data, some information, and the manner in which it is organized, may vary according to the particular program used. *Refer to the compliance supplement for the program being used for additional details*.

2. If appropriate default U-values for wall, roof/ceiling and floor are used (see Part 5.4, item B5), no special documentation is submitted. If default values are not used, prepare the appropriate Forms 3R for the various proposed construction assemblies either through the use of the program or by hand calculation (see *R-Value in the Glossary)*.

3. Prepare an input file describing the other thermal aspects of the proposed design according to the rules described in Part 5.4 and in the program's compliance supplement.

   Input values and assumptions must correctly correspond to the proposed design and conform to the required mandatory measures described in Chapter 2.

4. Generate a computer run to automatically calculate the Standard Design Energy Budget and the Proposed Design Energy Use.

5a. If the water heating system is a "standard system" as explained in Chapter 6, the water heating energy use is assumed to be the same for both the standard and proposed designs.

5b. If any other water heating system is to be used or if credit is being taken for a more conserving aspect of the water heating system, water heating energy use must be calculated as explained in Chapter 6. The computer printout must show the details of the water heating system that was modeled.

The building complies if the total energy use of the proposed design is the same or less than the standard design energy budget.

Professional Judgment

As explained in the next section, some modeling techniques and compliance assumptions applied to the proposed design are fixed or restricted. There is little or no freedom to choose input values for compliance modeling purposes. However, other aspects of computer modeling remain for which some professional judgment is necessary. In those instances, exercise proper judgment in evaluating whether a given assumption is appropriate.

Building departments have full discretion to reject a particular input, especially if the user has not substantiated the value with supporting documentation.

Two questions may be asked in order to resolve whether professional judgment has been applied correctly in any particular case:

- Is a simplifying assumption appropriate for a specific case?

- *If simplification reduces the predicted energy use of the proposed building when compared to a more explicit and detailed modeling assumption, the simplification is not acceptable* (i.e., the simplification must reflect higher energy use than a more detailed modeling assumption).

- Is the approach or assumption used in modeling the proposed design consistent with the approach or assumption used in generating the energy budget?

- *One must always model the proposed design using the same assumption and/or technique used by the program in calculating the energy budget unless drawings and specifications indicate specific differences that warrant conservation credits or penalties.*

Any unusual modeling approach, assumption or input value should be documented with published data and should conform to standard engineering practice.

For assistance in evaluating the appropriateness of particular input assumptions, call the Energy Hotline (see Chapter 1, Part 1.6) or call the vendor of the computer program (see Appendix F).

NOTE:

When creating any computer input file, use the space provided for the project title information to concisely and uniquely describe the building being modeled. User-designated names should be clear and internally consistent with other orientations and/or buildings being analyzed. Title names and explanatory comments should assist individuals involved in both the compliance and enforcement process.

5.4 PROPOSED DESIGN MODELING PROCEDURE

This section summarizes the modeling and output information used in demonstrating compliance with approved computer methods. *Program users and those checking for enforcement should consult the most current version of the user's manuals and associated compliance supplements for specific instructions on the operation of the program.*

Input data entered into each approved computer method may be organized differently from one to the next. As a result, it is not possible in this summary to present all variables in their correct order or hierarchy for any one program. The aim is to identify a generic type of input variable and explain how it should be treated in the context of properly modeling the proposed building design for compliance. Descriptions of particular values are cross-referenced to key outputs shown on the sample Computer Method Summary (C-2R) forms in Part 5.5. Modeling assumptions used by the computer methods to calculate the standard energy budget are outlined in Part 5.6.

The following general reference categories may be used to find specific input/output descriptions which are grouped accordingly:

MINIMUM CAPABILITIES

A. Building Information
B. Walls, Doors, Roofs/Ceilings and Floors
C. Fenestration
D. Shading Devices and Overhangs
E. Thermal Mass
F. Natural Ventilation
G. Mechanical Ventilation
H. Infiltration Gains and Losses and Reduced Building Envelope Air Leakage
I. Internal Gain & Thermostat Setpoints
J. Space Conditioning System Efficiency and Distribution (Duct) System Efficiency
K. Water Heating Efficiency and Distribution System
L. Radiant Barrier
M. Building Additions Modeled with or without Existing Buildings

OPTIONAL CAPABILITIES

N. Controlled Ventilation Crawl Space (CVC)
O. Zonal Control
P. Attached Sunspaces
Q. Combined Hydronic Space/Water Heating
R. Exterior Mass Walls
S. Solar Water Heating
T. Side Fin Shading
U. Gas-Fired Heat Pumps
V. Form 3 Report Generator

Computer Input	Proposed Design Modeling Procedure

A. Building Information

Project Title Information A1

The project title should be used to clearly identify and distinguish one project, building, unit plan and/or orientation from another. The general rule is to include as much title description as is useful.

Number of Dwelling Units A2

The number of dwelling units determines the value used for internal heat gain and the water heating energy budget in multi-family buildings.

When modeling an addition, consider the dwelling unit number as the fraction obtained by dividing the square foot area of the addition by the square foot area of the existing building plus addition.

Number of Stories A3

The number of habitable stories in the proposed design. A habitable story is defined as a story that contains space in which humans may work or live in reasonable comfort, and that has at least 50 percent of its volume above grade.

In the case of a second story addition modeled alone, the number of habitable stories in the proposed design should be input as "2".

Building Type A4

Building types are: Single Family (includes duplexes and halfplexes), Multi-Family (includes all other attached dwellings including condominiums), Addition, Existing-Plus-Addition or Alteration. The building type identifies for the computer programs which of the different modeling algorithms for internal heat gain and infiltration are used for the calculation of a particular energy budget (see Chapter 7, Part 7.2).

Front Orientation A5

This is a value that represents the rotation of the reference "Front" side or reference "Front" elevation of the building with respect to true north, expressed in degrees (see Figure 5-2). When compliance is demonstrated for all orientations, the reference orientation can be reported as North.

TRUE NORTH =	0	= True North
	90	= True East
	180	= True South
	270	= True West

NOTE:

The "front" or "entry" door of the building may not necessarily be located in the wall designated in the drawings as the "Front" elevation.

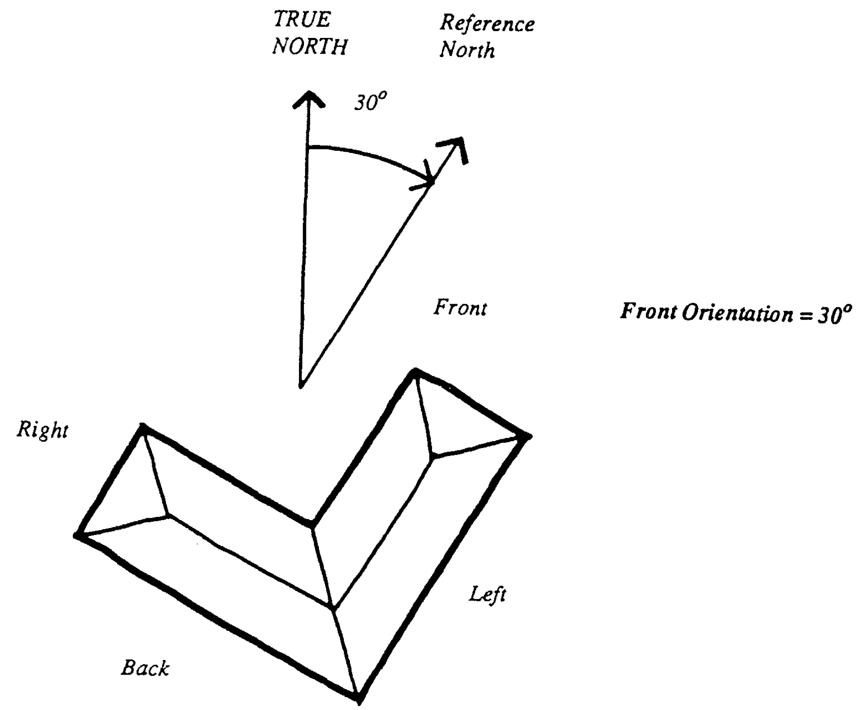


Figure 5-2: Front Orientation with respect to True North

Computer Input	Proposed Design Modeling Procedure
Total Conditioned Floor Area A6	Total conditioned floor area of the building, in square feet. See the *Glossary* for a full definition.
Conditioned Slab Floor Area	The conditioned slab area is the area of slab floor with conditioned space above and the ground (slab-on-grade) or unconditioned space below (raised slab). This input and the *Total Conditioned Floor Area* are used to determine the thermal mass modeled in the Proposed Design and the Standard Design.
Volume A7	Volume of all conditioned space, in cubic feet. This value is the product of total conditioned floor area and area-weighted average ceiling height.
Climate Zone A8	The climate zone identified allows the program to use the fixed weather data established by the Commission. Depending on the program, the city specified may automatically call the correct climate zone. Consult the Appendix D or the program compliance supplement.

Computer Input	Proposed Design Modeling Procedure
B	**Walls, Doors, Roofs/Ceilings & Floors**
Exterior Walls, Doors, Roofs/Ceilings and Raised Floors B1	Exterior surfaces are defined as surfaces which separate conditioned space from outdoor conditions or unconditioned spaces. See Unconditioned Space, Controlled Ventilation Crawl Space and the program compliance supplement for further information. Each exterior surface has associated with it a user-defined name (which may not appear on compliance output), area, U-value, orientation, tilt and absorptivity as described below. The mass effect of exterior masonry walls may be modeled by computer methods with that optional capability. In those cases, exterior wall inputs include thermal mass attributes described in Subpart 5.4E and in the program compliance supplement. Straw bales that are 23 inches by 16 inches are assumed to have a thermal resistance of R-30. (Performance data on other sizes of bales was not available at the time of publication of this manual.) The minimum density of load bearing walls is 7.0 pounds per cubic foot, or the actual density. Specific heat is set to 0.32 Btu/lb/°F. Volumetric heat capacity is calculated as density times specific heat (at 7 lb/ft^3 the volumetric heat capacity is 2.24 Btu/ft^3/°F.
Name B2	A user-defined name should be used to clearly distinguish one wall or ceiling from another. When a building is to be run for compliance in all four orientations, "front" and "rear" designations are recommended instead of "north" and "south" (see *Front* and *Back* in the *Glossary*). Note: user-defined names may be used and appear on input screens but the ACM must generate names such as WALL01 for compliance output

Computer Input	Proposed Design Modeling Procedure
Area B3	Net area of the exterior wall, basement wall/floor, roof/ceiling or raised floor, in square feet. The net area does not include the area of fenestration products and doors which are treated separately. Some programs may have the user enter a gross exterior wall area and automatically subtract the area of fenestration and doors. Consult the program compliance supplement. Exterior wall area is measured from the lowest finished habitable floor to the ceiling of the uppermost floor. Basement walls include below grade walls at depths of 2 feet, 2 to 6 feet, and greater than 6 feet. Above grade walls are modeled as conventional walls. Floor and ceiling areas include the thickness of exterior walls. Vaulted roof/ceiling areas must be calculated for the surfaces through which heat loss occurs (e.g., insulation in a flat ceiling area or in a sloped roof area). Skylight area is subtracted in computing net roof/ceiling areas.
Ground Floor Area B4	The conditioned ground floor area is defined as the conditioned slab-on-grade area of slab on grade building and the conditioned footprint area of a raised floor building.
U-Value B5	The U-value of the construction assembly, in Btu/(ft^2-hr-°F) (see the *Glossary*). Standard U-values shown in Table 5-1 may be used instead of completing and submitting a Form 3R. If a Form 3R is calculated (see *R-Value* in the *Glossary*), the "Total U-Value" from the bottom of the form is input. Ceiling U-values may be reduced by the ACM if radiant barriers are installed which meet certain installation criteria. See Subpart 5.4N for details. **NOTE**: In the case where metal framing is used the overall U-value of the assembly cannot be determined by using the Form 3R. To properly account for the high thermal conductivity of metal, the tables and methodology included in the Appendices for metal framing must be used to calculate a correct value. Also, values from Table G-16 may be used.

Computer Input	Proposed Design Modeling Procedure
Orientation B6	This is an input value representing the orientation of the exterior surface with respect to the reference "front" elevation. For example, the "left" elevation is 90°, the "rear" elevation is 180°, the "right" elevation is 270°, and the "front" elevation is zero degrees for a typical building. **NOTE:** The C-2R printout shows *actual orientation* of each opaque and fenestration surface *based on the rotation specified for Front Orientation*
Tilt B7	The tilt of the exterior surface is defined to be 0° for a horizontal (face up) roof/ceiling, 90° for a vertical wall and 180° for a floor (face down).
Solar Gains B8	Solar gains is either "Yes" for all exterior surfaces exposed to any direct sunlight or "No" for surfaces which do not receive direct solar gain (e.g., a wall separating conditioned space and a garage).

Table 4-1a: Standard U-Values of Wood Frame Roofs/Ceilings and Walls[1]

Roof/Ceiling Insulation	Framing Spacing	Reference[2] Name	U-Value
R-0[3]	16" o.c.	R.0.2X6.16	0.298
R-0[3]	24" o.c.	R.0.2X4.24	0.306
R-11[3]	16" o.c.	R.11.2X6.16	0.077
R-11[3]	24" o.c.	R.11.2X4.24	0.077
R-13[3]	16" o.c.	R.13.2X6.16	0.069
R-13[3]	24" o.c.	R.13.2X4.24	0.069
R-19	16" o.c.	R.19.2X8.16	0.051
R-19	24" o.c.	R.19.2X4.24	0.047
R-22	16" o.c.	R.22.2X10.16	0.0454
R-22	24" o.c.	R.22.2X4.24	0.041
R-30	16" o.c.	R.30.2X10.16	0.036
R-30	16" o.c.	R.30.2X12.16	0.034
R-30	24" o.c.	R.30.2X4.24	0.031
R-38	16" o.c.	R.38.2X12.16	0.030
R-38	16" o.c.	R.38.2X14.16	0.028
R-38	24" o.c.	R.38.2X14.24	0.025
R-49	16" o.c.	R.49.2X4.16	0.019
R-49	24" o.c.	R.49.2X4.24	0.019
Wall Insulation			
R-0[3]	16" o.c.	W.0.2X4.16	0.385
R-0[3]	24" o.c.	W.0.2X4.24	0.393
R-7[3]	16" o.c.	W.7.2X4.16	0.130
R-7[3]	24" o.c.	W.7.2X4.24	0.127
R-11[3]	16" o.c.	W.11.2X4.16	0.098
R-11[3]	24" o.c.	W.11.2X4.24	0.094
R-13	16" o.c.	W.13.2X4.16	0.088
R-13	24" o.c.	W.13.2X4.24	0.085
R-15	16" o.c.	W.15.2X4.16	0.081
R-15	24" o.c.	W.15.2X4.24	0.077
R-19	16" o.c.	W.19.2X6.16	0.065
R-19	24" o.c.	W.19.2X6.24	0.063
R-21	16" o.c.	W.21.2X6.16	0.059
R-21	24" o.c.	W.21.2X6.24	0.056
R-25	16" o.c.	W.25.2X6.16	0.046
R-29	16" o.c.	W.29.2X4.16	0.035
Solid core wood door (no insulation)		D.0.SCW	0.330

1. Based on ASHRAE Parallel heat Flow Calculation, ASHRAE Handbook of Fundamentals.
2. These Reference Names are taken from Appendix H.
3. Does not meet the minimum level required as a mandatory measure (see Chapter 2, Part 2.2).
4. Roof/ceiling assemblies whose reference names list 2x4 framing include an attic space.

Table 5-1b: Standard U-Values of Wood Frame Raised Floors[1]

Floor Insulation	Condition	Reference[2] Name	U-Value
R-0[3]	No crawl space	FX.0.2X6.16	0.241
R-0[3]	Crawl space	FC.0.2X6.16	0.097
R-11[3]	No crawl space	FX.11.2X6.16	0.071
R-11[3]	Crawl space	FC.11.2X6.16	0.050
R-13	No crawl space	FX.13.2X6.16	0.064
R-13	Crawl space	FC.13.2X6.16	0.046
R-19	No crawl space	FX.19.2X8.16	0.049
R-19	Crawl space	FC.19.2X8.16	0.037
R-21	No crawl space	FX.21.2X8.16	0.045
R-21	Crawl space	FC.21.2X8.16	0.035
R-30	No crawl space	FX.30.2X10.16	0.034
R-30	Crawl space	FC.30.2X10.16	0.028

1. Based on ASHRAE Parallel heat Flow Calculation, ASHRAE Handbook of Fundamentals.
2. The Names given to the standard assemblies used to calculate these U-values in Appendix H.
3. Does not meet the minimum level required as a mandatory measure (see Chapter 2, Part 2.2).

Table 5-1c: Standard U-Values of Wood Foam Panel Roofs/Ceilings and Walls[1]

Roof/Ceiling Insulation	Framing Spacing	Reference[2] Name	U-Value
R-14[3]	48" o.c.	RP.14.2X4.48	0.058
R-22	48" o.c.	RP.22.2X6.48	0.041
R-28	48" o.c.	RP.28.2X8.48	0.033
R-36	48" o.c.	RP.35.2X10.48	0.027
Wall Insulation			
R-14	48" o.c.	WP.14.2X4.48	0.062
R-22	48" o.c.	WP.22.2X6.48	0.044

1. Based on ASHRAE Parallel heat Flow Calculation, ASHRAE Handbook of Fundamentals.
2. The names given to the standard assemblies used to calculate these U-values in Appendix H.
3. Does not meet the minimum level required as a mandatory measure (see Chapter 2, Part 2.2).

Computer Input	Proposed Design Modeling Procedure
Slab-On-Grade B9	Slab floors coupled directly to the ground (i.e., poured directly on grade) fall into this category. Post-tensioned slabs suspended over a garage, for example, are treated as exterior (raised) floors but are included as part of the *Conditioned Slab Floor Area*. Thermal mass characteristics of slab floors are explained in Subpart 5.4E.
Slab Area B10	The gross area of slab-on-grade, in square feet. This value is needed for the program to calculate the net area of covered slab and the conditioned footprint area of the building.
Slab Edge Length B11	The length of slab edge through which there is heat loss, in feet. The slab edge length is fixed to assume 80 percent is carpeted or covered and 20 percent is exposed to conditioned air. Slab heat transfer is modeled through the slab edge. The heat flow is a function of the surface treatment of the slab, and the R-value and depth of any edge insulation (B12).
Slab Edge Insulation Depth and R-Value or F-2 Factor B12	The F2 factor defines the slab loss per linear foot of slab edge. The user specifies the insulation depth and R-value and the program calculates the F2 factor. Any portion of a slab edge located between conditioned space and an attached and enclosed conditioned space (e.g., a garage or crawl space) may be modeled as if R-7 insulation is installed to a depth of 16". In climate zones 1 and 16 only, slab edges adjacent to an entry slab may also be calculated as if R-7 insulation is installed to a depth of 16". The perimeter length of bermed (under ground) walls is modeled as slab edge.

NOTE:

In a building with a hydronic radiant slab floor heating system (see Chapter 8, Part 8.9), the required R-10 slab edge insulation must be installed. However, the slab must be modeled without credit for slab edge insulation (i.e., R-0 for Climate Zones 1-15 and R-7 for Climate Zone 16) for compliance purposes.

Table 5-1d: Standard U-Values of Steel Frame Walls[1]

Wall Insulation	Insulation Sheathing R-Value	Framing Type	Framing Spacing	U-Value[3]
R-11[3]	0	2x4	16" o.c.	0.202
R-11	7	2x4	16" o.c.	0.084
R-11[3]	0	2x4	24" o.c.	0.173
R-11	7	2x4	24" o.c.	0.078
R-13[3]	0	2x4	16" o.c.	0.195
R-13	7	2x4	16" o.c.	0.082
R-13[3]	0	2x4	24" o.c.	0.165
R-13	7	2x4	24" o.c.	0.077
R-15[3]	0	2x4	16" o.c.	0.189
R-15	7	2x4	16" o.c.	0.077
R-15[3]	0	2x4	24" o.c.	0.158
R-15	5	2x4	24" o.c.	0.088
R-19[3]	0	2x6	16" o.c.	0.162
R-19	7	2x6	16" o.c.	0.075
R-19[3]	0	2x6	24" o.c.	0.135
R-19	4	2x6	24" o.c.	0.088
R-21[3]	0	2x6	16" o.c.	0.157
R-21	5	2x6	16" o.c.	0.088
R-21[3]	0	2x6	24" o.c.	0.130
R-21	4	2x6	24" o.c.	0.086
R-22[3]	0	2x6	16" o.c.	0.158
R-22	5	2x6	16" o.c.	0.088
R-22[3]	0	2x6	24" o.c.	0.132
R-22	4	2x6	24" o.c.	0.086

1. Based on ASHRAE Parallel heat Flow Calculation, ASHRAE Handbook of Fundamentals.
2. The U-value must be no greater than 0.088 to comply. See also Appendix I, Table I-1.
3. Does not meet the minimum level required as a mandatory measure (see Chapter 2, Part 2.2).

C. Fenestration

Fenestration C1

Fenestration products include all windows, skylights and exterior doors with glazing (see Chapter 2, Part 2.3 and the *Glossary*.) All fenestration must be modeled if it separates conditioned space from the outside or conditioned space from unconditioned space. In some special cases, fenestration is not modeled as exterior surface (e.g., in the case of a controlled ventilated crawl space or an unheated sunspace) as explained in the program compliance supplement. See *Unconditioned Space* later in this section and the program compliance supplements.

Fenestration Name C2

The user-defined name should be used to indicate the type of fenestration product and associated shading.

When a building is to be run in all four orientations, "front" and "back" designations should be used instead of "north" and "south" (see *Front* in the *Glossary*).

Area C3

The sash or frame opening area of the fenestration product, in square feet (see Glossary). The area calculated from the nominal or rough opening dimensions is generally acceptable. The full area of French doors must be included, as well as the rough opening of greenhouse/garden windows.

A greenhouse/garden window is a window that projects from the building but does not extend to the ground and is not intended for use as a habitable space (e.g., used for shelves).

U-Value C4

The rated U-value of the fenestration product, in Btu/hr-ft^2-°F. This is the U-value which the manufacturers display as a label on all windows and skylights. See Chapter 2, Part 2.3 for a discussion of window, glass door and skylight ratings.

Computer Input	Proposed Design Modeling Procedure
Orientation C6	The orientation of the glazing surface with respect to the "front orientation" (see Figure 5-2).

The "left" elevation is 90°, "back" elevation is 180°, right elevation is 270°, and "front" elevation is 0° for a typical building. See A5, *Front Orientation*, and B6, *Wall Orientation,* in this section.

> NOTE:
>
> The C-2R printout shows *actual orientation* of each opaque and glazing surface *including the rotation specified for Front Orientation.*

Tilt C7

The tilt of the fenestration is defined to be 0° for a horizontal skylight and 90° for a vertical window or clerestory. The actual tilt of the fenestration should be entered (e.g., 18° for a skylight in a 4:12 roof pitch).

Operable Window Type C8

Acceptable opening types are Slider, Hinged (casement, French door, awning or hopper), or Fixed (picture window). The default for windows is Slider. To determine the standard design, the assumption is that all fenestration openings are operable slider type.

The area of operable fenestration is important in the natural ventilation effectiveness calculated by the program.

When credit for hinged operable fenestration is taken, all fixed fenestration areas must also be accounted for as part of the calculation of total vent area:

$$\mathbf{Vent}_{area} = (\mathbf{Area}_{slider} \times 0.1) + (\mathbf{Area}_{hinged} \times 0.2) + (\mathbf{Area}_{fixed} \times 0.0$$

When the area of hinged windows are entered, the area of sliders must also be entered and the area of fixed windows must equal the difference between the total fenestration area and the sum of the areas of the sliders and hinged fenestration or a program error will result.

Free vent area is divided up into 50 percent of the total free vent area as inlet area and 50 percent of the free vent area as outlet area. Although this calculation is done automatically within the program, the equation is needed to area-weight height differences between inlet and outlet vents as explained in F2.

D. Shading

Shading Characteristics D1

Shading can be defined as a fixed overhang and/or side fins relating to a particular glass area; as a fixed exterior screen or shade with a specified solar heat gain coefficient; or as an interior movable device with an overall glass/shade solar heat gain coefficient. For a full explanation of *Shading*, see the *Glossary* and consult the program compliance supplement.

SHGC Fenestration D2

This SHGC for the fenestration product which includes the shading effects of framing and dividers is obtained from manufacturer's literature, product label, or from Table G-7 (see *Solar Heat Gain Coefficient* in the *Glossary*).

Interior Shade D3

The SHGC for interior devices is determined based on the following descriptions:

Descriptor	Interior Shading Device
Standard	Draperies, Translucent Roller Shades, or No Special Interior Shading - Default Interior Shade
Blinds	Venetian Blind, Vertical Blind, MiniBlind)
OpRollShd	Opaque Roller Shades Only

No other interior shading devices or attachments are allowed credit for compliance with the building efficiency standards. That is, no custom shading devices are allowed to be used for compliance.

When compliance credit is claimed for any interior shading device other than "Standard," that device must be installed and present at final inspection.

A drapery is modeled when "Standard" or no special interior shading is specified for a window. If the output specifies *Standard*, it will note that a drapery is modeled, but it is not required to be installed and present at final inspection.

The default interior shading device for skylights is *None* and skylights (glazing tilted less than 60 degrees) are the only fenestration surfaces allowed to use *None* for the interior shading device.

Computer Input	Proposed Design Modeling Procedure
Exterior Shade D4	Credit for exterior devices is determined from the description of the exterior shading device:

Descriptor	Exterior Shading Device
Standard	Bug Screen
WvnScrn	Woven SunScreen
LvrScrn	Louvered SunScreen
LSASnScrn	Low Sun Angle (LSA) Sunscreen
RlDwnAwng	Roll-down Awning
RlDwnBlnds	Roll -down Blinds or Slats
None	None (Skylights Only)

Note that None is only allowed for skylights and is the default exterior shade for skylights.

Height of Shaded Fenestration D5

Height of fenestration to be shaded, in feet.

In most programs, fenestration height is used only to establish the geometry of the shading condition for overhangs and fins, not to compute fenestration area (which is entered elsewhere.)

For a particular overhang, the area-weighted average height may be used if combining different windows is judged appropriate according to Part 5.2 of this chapter.

Width of Shaded Fenestration D6

Width of fenestration to be shaded, in feet.

Fenestration width is used generally to establish the geometry of the shading condition for overhangs and fins, not to compute fenestration area (which is input elsewhere).

An average fenestration width may be used if combining different windows is judged appropriate according to Part 5.2 of this chapter.

Overhangs D7

Dimensions which describe an overhang above the fenestration, in feet: Depth of the overhang, vertical distance from the top of the fenestration to the overhang, extension of the overhang at the sides, height of the overhang flap (depending on the program). Consult the program compliance supplement for further information.

Computer Input	Proposed Design Modeling Procedure
Fins D8	Dimensions which describe side fins to the left and/or right of the fenestration, in feet: Depth of fins, extension of fins above the fenestration, distance from the fins to the fenestration and the extension of fenestration below the fins (depending upon the program). Consult the program compliance supplement for further information.
Substantially Shaded Fenestration D9	Substantially shaded fenestration may be modeled with an exterior solar heat gain coefficient of 0.20. For more details on the requirements that must be met, refer to *Solar Heat Gain Coefficient* in the *Glossary*.

E. Thermal Mass

In the 1998 standards, thermal mass was removed as a requirement for the Prescriptive Package that is the basis for the Standard Design used to determine the energy budget for the performance approach. Thermal mass credit is now restricted to buildings designed to take advantage of thermal mass such as passive solar designs. For typical buildings there is no credit for thermal mass because thermal mass is modeled the same for both the Proposed Design and the Standard Design. Thermal mass receives credit only when the amount of mass in the Proposed Design exceeds a high mass threshold.
Refer to the program compliance supplement to learn more about specific thermal mass modeling techniques and optional capabilities.

Computer Input	Proposed Design Modeling Procedure
Mass Material Name E1	A user-defined name for a thermal mass material not already included as part of the program's materials library.
Surface Area E2	Surface area of the thermal mass, in square feet. If both surfaces of an interior mass wall are exposed to conditioned space, use half the thickness of the wall and the total area of both wall surfaces. Both surfaces are coupled to zones called "House" (see E8). The surface area of covered slab-on-grade is the calculated exposed slab area subtracted from the total gross slab area.

Computer Input	Proposed Design Modeling Procedure
Thickness E4	Thickness of the thermal mass, in inches. If both surfaces of a solid interior mass wall such as grouted concrete block are directly exposed to conditioned air, the full thickness of the wall should be assigned to the mass element which is then coupled to two "House" zones as explained in E3 and E8.
Volumetric Heat Capacity E5	Heat capacity of one cubic foot of the material, in Btu/ft^{3}°F. Consult the compliance supplement for the specific program being used to select the appropriate value for a generic mass material listed in Table G-13.
Conductivity E6	Thermal conductivity of the mass material, in Btu/hr-ft^{2}-°F. Consult the compliance supplement for the specific program being used to select the appropriate value for a generic mass material.
Surface Resistance E7	Heat transfer at the surface of the mass is expressed as thermal resistance, in hr-ft^{2}-°F/Btu. This value is used to account for a treatment such as carpet which, like any "covered" surface, is assumed to have a surface resistance of R-2.0. In modeling a slab-on-grade building, all mass area that is not exposed is assumed to be covered.
Mass Coupling E8	The coupling of the thermal mass defines which building zone (e.g., "house") or temperature condition the mass surface is connected to. Each side of the mass is coupled either to a conditioned space, an unconditioned space or the ambient (outdoor) conditions. Thermal mass is considered "interior" if all of its surface area, such as both sides of a masonry partition are exposed to the conditioned space. Thermal mass coupled to conditioned space on one side and exposed to outdoor conditions on the other side is "exterior" mass. The CF-1R and C-2R forms (see Part 5.5 and Appendix A) make clear which type of mass is included in the proposed design.

F. Infiltration/Ventilation and Reduced Building Envelope Air Leakage

Approved computer programs use a default building envelope air leakage (expressed in terms of Specific Leakage Area, SLA) for proposed designs when the user does not intend to take compliance credit for building envelope sealing. The default is set at 4.9 SLA except for dwellings using non-ducted HVAC systems where the default SLA is 3.8 for both the Proposed and Standard Designs. Careful attention to building envelope sealing would result in significantly lower SLA levels which may be modeled subject to verification by a HERS rater.

Reduced Building Envelope Air Leakage through Diagnostic Testing F1

Compliance credit can be taken for reduced building envelope leakage verified through diagnostic blowerdoor testing as described in Chapter 4.

There are special mechanical ventilation requirements when the building is designed for low building envelope leakage and mechanical **supply** ventilation requirements when diagnostic testing indicates that the building is "unusually tight." These are described in Chapter 4.

Mechanical Ventilation Wattage of Ventilation Supply and Exhaust Fans F3

The total power consumption of the continuous supply ventilation fans and continuous exhaust fans are input when compliance credit is taken for reduced building envelope leakage and mechanical ventilation is installed.

Mechanical Ventilation cfm of Ventilation Supply and Exhaust Fans F4

The volumetric capacity of continuous supply fans and continuous exhaust fans are input when continuous mechanical ventilation is installed.

Reduced Duct Leakage F5

If compliance credit is **not** taken for reduced building envelope air leakage through diagnostic testing, a special "default" compliance credit can be taken for building envelope leakage reduction resulting from reduced duct leakage. To qualify for this credit all requirements of section 4.4.I4 *Duct Leakage* must be met. Compliance credit is provided for a "default" reduction in Specific Leakage Area of 0.50

Computer Input	Proposed Design Modeling Procedure
Air Retarding Wrap F6	If compliance credit is **not** taken for reduced building envelope air leakage through diagnostic testing, a special "default" compliance credit can be taken for building envelope leakage reduction resulting from installation of an air retarding wrap (i.e., housewrap). There are special qualifications for the use of these wraps to get credit which are described in Chapter 4. When compliance credit is taken for an air retarding wrap, the computer program must automatically include the air retarding wrap and the required specifications in the *Special Features and Modeling* Assumptions section of the CF-1R and CF-2 to facilitate inspection by the local enforcement agency. Compliance credit for an air retarding wrap does not require HERS rater verification. Compliance credit is provided for a "default" reduction in Specific Leakage Area of 0.50.
Natural Ventilation for Cooling F7	Approved compliance programs assume that windows are opened for natural ventilation when outside temperatures are conducive for providing outside cooling. For buildings with typical thermal mass levels, default assumptions for natural ventilation are used. For high mass buildings, compliance credit can be taken for increased free ventilation window area and increased ventilation height.
Ventilation Height Difference F8	A height difference of 2 feet is input for one-story dwelling units (even if the dwelling unit occurs in a two- or three-story building). A value of 8 feet is input for two- and three-story dwelling units. A different value for the height difference between horizontal center lines of inlet and outlet openings corresponding to the actual building design is acceptable if properly documented. An area-weighted calculation is required to document credit for any value larger than the standard value.

G. Internal Gain & Thermostat Setpoints

Internal Heat Gain G1

Total internal heat gain per day from occupants, lights, appliances and other heat-generating equipment is automatically fixed by the program according to the number of dwelling units in the building and the total conditioned floor area. The hourly schedule of internal gain is also fixed.

In modeling additions, the internal heat gain associated with the addition as a separate compliance entity is also calculated by the program on a prorated basis as compared with the existing-plus-addition (see Chapter 7, Part 7.3).

Internal gain related to modeling a zonally-controlled space is also automatically fixed by the program. The living zone and sleeping zone are assigned various portions of the internal gain according to specific rules. (see L1, *Zonal Control* in this section).

Thermostat Setpoints G2

Thermostat setpoints for heating, cooling and venting are fixed by the program based on setback or no setback. Settings are inaccessible by the program user. Special thermostat settings for the zonal control model are also built in and automatically used when zonal control is specified in computer methods approved with that approach (see L1, *Zonal Control* in this section).

Certain types of heating and cooling equipment are exempt from the setback thermostat mandatory measure (see Chapter 2, Part 2.3). When no setback thermostat is installed, the computer method must assume a 66°F night setback heating setpoint (see Part 5.6).

The program also allows the specification of *unconditioned zones* with thermostats set to insure that no heating or cooling occurs in those areas (see Subpart 5.4K, *Unconditioned Space*).

Computer Input	Proposed Design Modeling Procedure
H.	**Space Conditioning System**
Heating System Type H1	Heating system types include gas, heat pump and electric resistance. Gas refers to any non-electric fuel such as natural gas or propane. **Hydronic Space Heating** (see Subpart 5.4Q) and **Active Solar Space Heating** (see Subpart 5.4S) are covered later in this section.
Heating System Efficiency H2	For a central gas furnace, the minimum Annual Fuel Utilization Efficiency (AFUE) is 78 percent or 0.78. Non-central units such as gas wall furnaces may have a lower AFUE rating. For heat pumps, the minimum Heating Seasonal Performance Factor (HSPF) is 6.6 for package units or 6.8 for split system. (See *AFUE* and *HSPF* in the *Glossary*). For electric baseboard heating, an HSPF of 3.41 or ACOP of 1.00 is input; for electric radiant panels, an HSPF of 3.55 or ACOP of 1.04 is entered. For through-the-wall heat pumps, model a 6.6 HSPF with no duct efficiency credits (assume a default R-4.2 ducts in attic). For central air-conditioning heat pumps that meet a COP requirement, assume the actual duct conditions and calculate the HSPF as 3.2 x COP - 2.4. When no equipment has been specified at the time of the compliance run, minimum efficiencies are recommended to ensure that any equipment of minimum or higher efficiency may later be installed. For equipment that is not certified, such as radiant heat ers, the efficiency value modeled must be based on either manufacturers data or an approved calculation method.
Cooling System Type H3	The cooling system is a *split system* air conditioner or heat pump, or a *packaged* air conditioner or heat pump. When mechanical cooling will not actually be installed, see the note under H4.
Cooling System Efficiency H4	Enter the Seasonal Energy Efficiency Ratio (SEER) for both air conditioners and heat pumps. For equipment not tested for SEER (e.g., greater than 65,000 Btu capacity) use the EER in place of SEER. NOTE: If no mechanical cooling is installed, enter a *SEER of 10.0 for split systems*.

Computer Input	Proposed Design Modeling Procedure

I. Duct Efficiency

For the 1998 standards, the Commission has approved new algorithms and procedures for determining duct efficiency, and has created new options for compliance credit for improvements that can be made that will increase duct efficiency. These procedures are described in Chapter 4.

J. Water Heating

All Inputs J1 — All computer inputs for water heating correspond to the variables explained in Chapter 6.

K. Unconditioned Space

The ability to model an unconditioned space in the building is an optional modeling capability of approved computer methods. Consult the compliance supplement for specific details on what types of unconditioned spaces and how a particular program can model the proposed building design.

Unconditioned Zone Characteristics K1 — A computer method may have a variety of capabilities that can model one or more unconditioned spaces or "zones" adjacent to conditioned space. Enclosed, unheated areas such as sunspaces, unheated storage areas and crawl spaces may be modeled explicitly if the program is approved to accurately account for the thermal interactions between conditioned and unconditioned zones. *Garages and conventional attic spaces may not be modeled as unconditioned zones.*

Except for crawl space modeling explained under 5.4L, **Controlled Ventilation Crawl Space**, the following general descriptions cover other types of unconditioned spaces that can be modeled for compliance as part of the proposed design. The number of unconditioned spaces that can be modeled is limited only by the capabilities of the approved computer method.

Computer Input	Proposed Design Modeling Procedure
Exterior Walls, Doors, Roofs/Ceilings, and All Floors K2	Surfaces that separate unconditioned space from the ambient (outdoor) temperature are considered "exterior." Surfaces that separate unheated space from heated space are treated differently as part of the *Coupling to Conditioned Space* (see K8). The name, area, U-value, orientation, tilt, absorptivity and slab characteristics of each opaque surface are input in essentially the same manner as for conditioned zones. See Subpart 5.4B, **Walls, Doors, Roofs/Ceilings and Floors** for further information.
Fenestration K3	Fenestration attributes are the same as those relating to conditioned zones described in Subpart 5.4C, **Fenestration**.
Shading K4	Shading characteristics are the same as those defined in Subpart 5.4D, **Shading**.
Thermal Mass K5	Thermal mass inputs are generally the same as those described in Subpart 5.4E, **Thermal Mass**. One exception is the amount of solar gain targeted to the mass surfaces. This "Absorbed Insolation Fraction" or "Solar Gain Distribution Factor" is automatically fixed at zero for conditioned space but is a restricted variable within an unconditioned space. See the program compliance supplement for further instructions.
Infiltration and Ventilation K6	The same rules apply as explained in Subpart 5.4F, **Infiltration/Ventilation**.
Thermostat Setpoints K7	Thermostat setpoints are fixed by the program to insure that no heating or cooling will occur.
Coupling to Conditioned Space K8	The thermal connection between conditioned and unconditioned spaces is divided into conductive and convective components. The conductive heat flow is a function of the U-value and area of the surfaces that separate the zones. The convective coupling is defined according to the actual inlet and outlet area characteristics which define ventilation between the zones. If mechanical ventilation is to be installed, the electrical energy use of the fan must be accounted for as defined in the computer method compliance supplement.

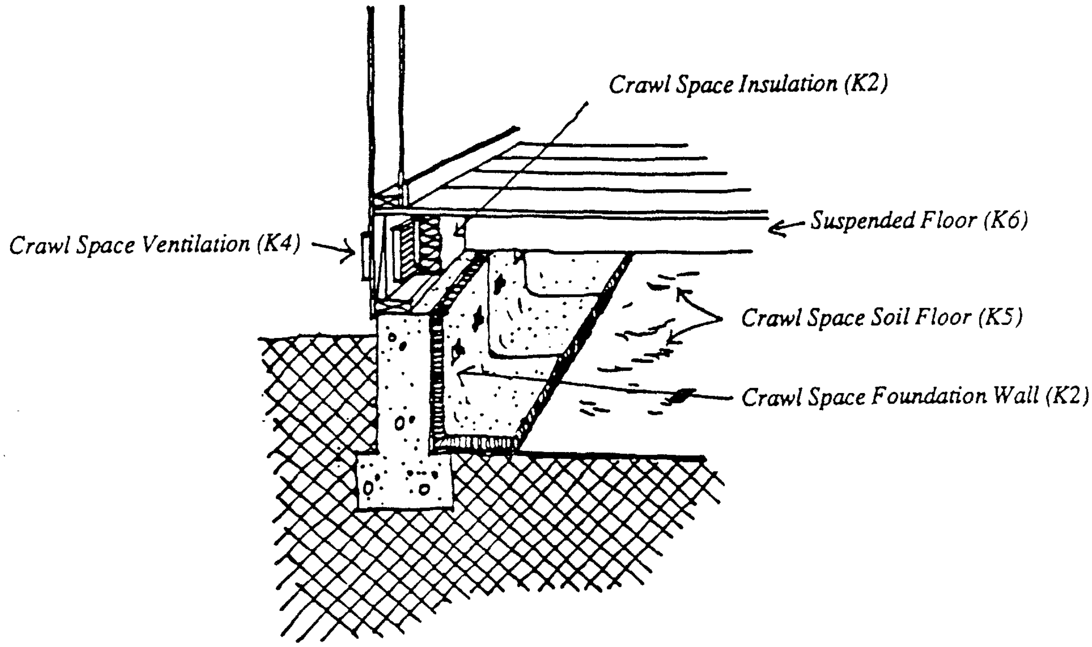


Figure 5-3: Controlled Ventilation Crawl Space

Table 5-3: Crawl Space Soil Slab Heat Loss Rate (F2) Factor

Insulation Length Along Crawl Space Soil Floor (inches)	R-Value of Insulation R-0	R-5	R-11	R-13	R-15	R-19	R-21
0	0.42	0.42	0.42	0.42	0.42	0.42	0.42
20	0.42	0.33	0.30	0.29	0.28	0.27	0.27
68	0.42	0.29	0.24	0.23	0.22	0.20	0.20

1. Based on ASHRAE Method of Calculating Transmission Heat Loss, 1989 ASHRAE Handbook of Fundamentals.

Computer Input	Proposed Design Modeling Procedure
L.	**Controlled Ventilation Crawl Space (CVC)**
Crawl Space Model L1	A crawl space may be modeled as a separate unconditioned zone only when reduced crawl space vent areas are implemented. This approach is part of a Commission-approved exceptional method that establishes the crawl space soil as a type of slab with heat loss factors similar to the slab edge loss (F2) factors explained in input B11. Refer to the Chapter 8, Part 8.7 for details on the requirements pertaining to installation of foundation wall insulation, drainage, ground water and soils, ventilation and crawl space ground cover. (See Figure 5-3). Computer programs approved for modeling the crawl space automatically fix certain variables such as crawl space heat capacity (1.4 x suspended floor area), infiltration rate (0.22 air changes per hour), soil conductivity (0.60 Btu/hr-ft^2-ºF) and volumetric heat capacity (27 Btu/ft^3-ºF).
Crawl Space Foundation Wall L2	The foundation wall and insulation are modeled as it will be built including band joist area and the stem wall above and below outside grade level. The stem wall below the outside grade and above the crawl space grade may be considered a bermed wall and assumed to be fully shaded.
Crawl Space Volume L3	The average crawl space height from the ground to the bottom of the subfloor times the floor area above the crawl space, in cubic feet.
Crawl Space Ventilation L4	One half the actual total vent area shall be considered inlet area and one half outlet area. The crawl space ventilation area and type shall be shown on the plans and specifications.
Crawl Space Soil Floor L5	The crawl space soil floor is modeled as a four inch thick mass element with its actual area. Slab edge losses are modeled according to the crawl space perimeter length and the following special slab heat loss rate (F2) factor (Table 5-3).
Suspended Floor L6	The suspended (raised) floor between the crawl space and conditioned space is modeled as built: actual area and U-value (with indoor air films assumed for both sides of the surface).

Computer Input	Proposed Design Modeling Procedure
M.	**Zonal Control**
Zonal Control Features M1	Zonally controlled space heating and cooling systems must meet the eligibility requirements explained in Chapter 8, Part 8.8. These systems must have a separate thermostat in the "living zone" and "sleeping zone" of the dwelling unit and a nonclosable opening area between the zones of 40 square feet or less.

A dwelling unit may meet zonal control eligibility requirements by having one or more individual HVAC units serving only the "Living" zone and one or more units serving only the "Sleeping" zone as an alternative to a single central HVAC unit with zonal control capabilities.

Approved computer programs model a zonally controlled system using certain built-in assumptions: (see Figure 5-4).

- User-defined Living and Sleeping Zones, each with its own thermostat setpoints for heating, cooling and venting according to fixed occupancy schedules. These schedules include setback and setup temperatures for each zone throughout the day. (Each Living or Sleeping Zone created for modeling purposes may be comprised of one or more actual HVAC zones.)
- A U-value of 0.293 is used for uninsulated wood frame walls between zones.
- A U-value of 20.0 is used for nonclosable openings.
- Lightweight mass heat capacity proportioned according to each zone's percent of the total floor area.

Computer Input	Proposed Design Modeling Procedure
	• Internal gain distribution is 20,000 Btu + 15 Btu/ft^2 per day for the Living Zone and 15 Btu/ft^2 per day for the Sleeping Zone according to a fixed hourly schedule. When cooling is not installed but is considered "optional". zonal credit for both heating and cooling systems can be taken as long as: • All the zonal control criteria are met; • The system is prepared for the cooling system (i.e., designed to be interconnected with the central furnace and with ducts sized for the air flow required for cooling); • Common ducts are sized to handle the cooling air flow (cubic feet per minute); • The location of the outdoor compressor is identified; and, • The electrical panel is prepared to handle the load for a future air conditioner.
Variable Inputs M2	All physical attributes of the building are entered as part of either the Living Zone or Sleeping Zone according to the proposed building design. Fenestration and shading, walls, roofs/ceilings, floors, thermal mass and ventilation are all entered for each conditioned zone. The actual nonclosable area between zones is modeled, as well as the areas and U-values of surfaces between zones.

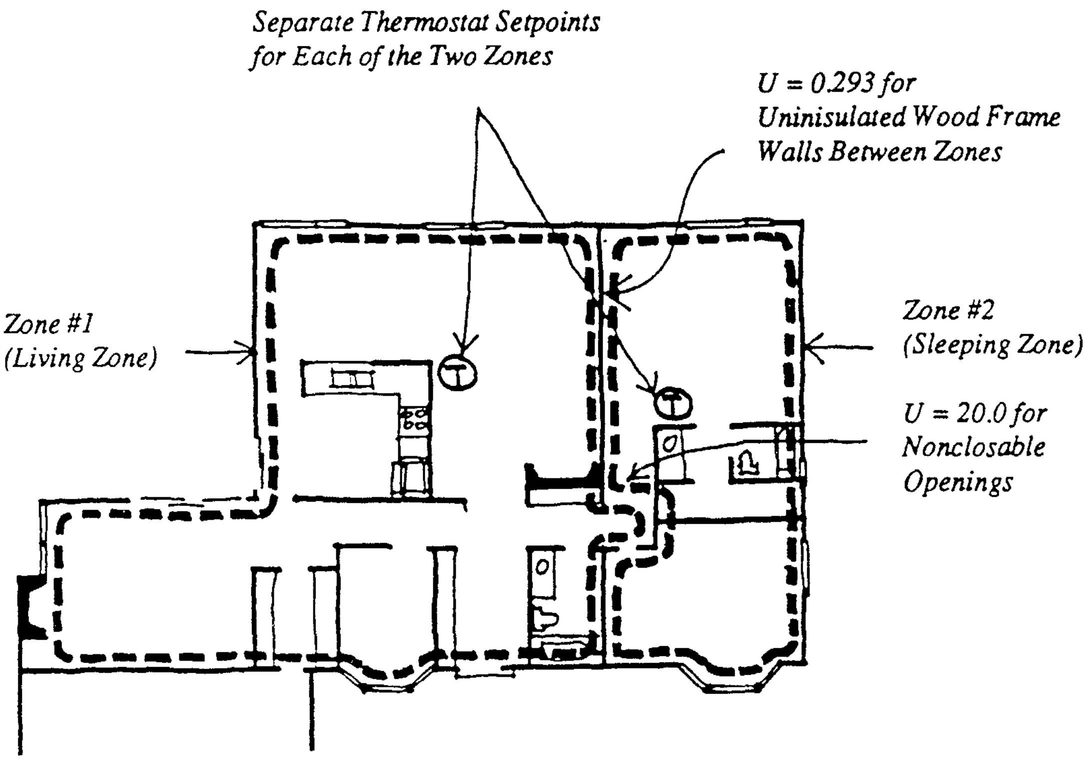


Figure 5-4: Zonal Control Modeling Assumptions

Computer Input	Proposed Design Modeling Procedure

N **Radiant Barrier**

Energy credit for truss mounted radiant barrier installations is calculated as a ceiling insulation modifier to the U-value and is also reflected in attic temperatures that result in better HVAC distribution efficiencies for ducts in an attic below a radiant barrier.

Radiant barriers must meet specific eligibility and installation criteria as specified in Chapter 8, Part 8.13. The radiant barrier and installation criteria will be listed on the CF-1R and CF-2R as a *Special Features and Modeling Assumptions*.

Computer Input	Proposed Design Modeling Procedure
Radiant Barriers N1	Installation of radiant barriers can improve building energy efficiency, particularly in hot climate zones. Radiant barriers are defined as fabric-type materials installed in the ceiling/roof assembly and having an emissivity of 0.05 or less. To use the Commission-approved method of calculating the energy savings of radiant barriers, all installation and eligibility criteria listed in Chapter 8, Part 8.13 must be met. The radiant barrier energy credit is an adjustment to the ceiling U-value allowed when the ceiling is adjacent to an attic with a radiant barrier. Consult the *User's Manual* for each approved computer method to determine required inputs for radiant barriers. A radiant barrier credit is also available to account for the effects of radiant barriers on duct efficiency. This is described in Chapter 4 under duct efficiency.
O.	**Solar and Wood Stove Boiler Water Heating**
All Inputs O1	All inputs for energy credit for use of solar or wood stove boiler-assisted water heating correspond to the variables explained in Chapter 6. Solar credit is provided through a Solar Savings Fraction (SSFj) derived from an f-Chart analysis.
P.	**Combined Hydronic Space/Water Heating**
All Inputs P01	All inputs for combined hydronic space and water heating correspond to the variables explained in Chapter 6.

Computer Input	Proposed Design Modeling Procedure
Q.	**Dedicated Hydronic Space Heating**
Hydronic System Q1	A hydronic heating system is defined as one that has its space heating device(s), storage tank(s), distribution system and other components interconnected by common hot water piping. The Commission-approved method for calculating the overall efficiency of a hydronic space heating system is explained in Chapter 8, Part 8.9. See Chapter 6, Part 6.5 for information on combined hydronic space and water heating systems and how to calculate the energy use. The Effective AFUE (minimum 0.80 AFUE) is obtained through that calculation method and input into the programs as the heating system efficiency with a Duct Efficiency Factor of 1.00 (ducts are assumed to be located in conditioned space). If pipes are located in unconditioned space the AFUE must be adjusted for pipe losses. Solar water heating integrated into a combined hydronic system is explained in Chapter 6, Part 6.3. Active Solar Space Heating is discussed in section S below and in Chapter 8, Part 8.16.
R.	**Building Additions**
Various Inputs, Addition Alone R1	Internal gains are based on the fractional dwelling unit. The dwelling unit entry is determined by calculating: $\dfrac{\text{Addition}}{\text{Existing+Addition}}$ Credit for zonal control is not allowed for an addition modeled alone.
Existing Plus Addition R2	All inputs are explained in Chapter 7, Part 7.3.

Computer Input	Proposed Design Modeling Procedure
S.	**Active Solar Space Heating**
Active Solar Space Heating System S1	To determine the energy savings of an active solar space heating system, it is first necessary to obtain the total space heating load per month in order to enter those values into an approved version of the f-Chart program. Therefore, the monthly space heating load must be analyzed using an approved computer method so that the solar space contribution can be assessed (see Chapter 8, Part 8.16). Except for monthly space heating loads, all other values that are entered into f-Chart must be consistent with the fixed values listed in Chapter 6, Part 6.3 and Chapter 8, Part 8.16, and the actual active solar hot water system design. Since building or dwelling unit monthly heating loads are not required as part of the standardized compliance reports (see Part 5.5), a special output report from the computer method may be needed. Consult the program compliance supplement for details, then proceed to Chapter 8, Part 8.16.

5.5 COMPUTER METHOD DOCUMENTATION

Standard Reports

For consistency and ease of enforcement, the manner in which building features are reported by compliance computer programs is standardized. Commission approved computer programs must automatically produce compliance reports in this standard format. These standard reports are:

- Certificate of Compliance, CF-1R
- Computer Method Summary, C-2R

Both the CF-1R and the C-2R must have two highly visible sections, one for special features and modeling assumptions, and a second for features requiring verification by approved home energy rating system (HERS) providers/raters. These two sections serve as "punchlists" for special consideration during compliance verification by the local building department and HERS rater. Items listed in the *Special Features and Modeling Assumptions* section indicate the use for compliance of unusual features or assumptions, and call for special care by the local building department. Items listed in the *HERS Required Verification* section are for features that rely on diagnostic testing and independent verification by approved HERS providers/raters to insure proper field installation. Diagnostic testing and verification by HERS providers/raters is in addition to local building department inspections.

Figures 5-5a through 5-6b illustrate the CF-1R and C-2R forms for sample buildings generated by the public domain computer program, CALRES2.

Other Forms

Some additional forms are required but are not required to be printed out by the computer methods. These are:

- Mandatory Measures Checklist, MF-1R
- Installation Certificate, CF-6R
- Insulation Certificate, IC-1

Other forms and supporting documents may be applicable to a particular set of calculations:

- Construction Assembly U-Value, Form 3R
- Certificate of Field Verification and Diagnostic Testing, Form CF-4R
- Solar Heat Gain Coefficient Worksheet, Form S
- Manufacturer's Specifications for HVAC & Water Heating Equipment

5.6 STANDARD DESIGN ASSUMPTIONS

Each approved computer method must automatically calculate the energy budget for the standard design (see Part 5.2). This feature of the computer method must define the *custom budget* or *Standard Design run* based upon data entered for the *Proposed Design* using all the correct fixed and restricted inputs. These inputs cannot be altered in the *Proposed Design* except as specified in Part 5.4 or the computer method compliance supplement.

The computer method defines the standard design by modifying the geometry of the Proposed Design and inserting the building features of Package D as specified in the Standards. This process is built into each approved computer method (ACM) and the user cannot access it. Key details on how the standard design is created and calculated by the computer methods, including the listing of fixed and restricted input assumptions, is available in the latest edition of the Commission's ***Residential Alternative Calculation Methods Approval Manual***

Standard Design: General Approach

The basis of the standard design is Package D, contained in Tables 3-Z1 through 3-Z16 in Chapter 3, Part 3.4.

The standard design assumes the same total conditioned floor area, conditioned slab floor area, and volume as the proposed design, and the same gross exterior wall area as the proposed design, except that the wall area in each of the four cardinal orientations is equal. The standard design uses the same roof/ceiling area, raised floor area and slab-on-grade area and perimeter as the proposed design, assuming the standard insulation R-values listed in Tables 3-Z1 through 3-Z16.

Total fenestration area is determined by the package specification and evenly distributed between the four cardinal orientations. Solar heat gain coefficients are those listed in Packages D, and no fixed shading devices such as overhangs are assumed.

The standard design includes minimum efficiency heating and cooling equipment, as well as the minimum duct R-value with ducts in a vented attic. The water heating system of the standard design is assumed to be equal to the water heating energy budget (explained in Chapter 6).